Congestion Pricing with Minimal Public Opposition

The Use of High-occupancy Toll Lanes and Positive Incentives in Israel

Discussion Paper

183

Roundtable

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Introduction

Congestion tolling has been advocated as an efficient policy to reduce traffic congestion for more than 100 years, starting from Pigou (1918) and continuing today, as for example Anas, (2020). Nevertheless, although congestion has increased dramatically over the years and expanded both spatially (i.e., larger parts of the network) and temporally (i.e., duration of the congestion), congestion tolls remain. Political proposals to initiate congestion tolls often fail (Hong Kong 1987, Edinburgh 2006, New York, 2007[1] and Manchester 2008). The limited support for congestion tolls reflects the perceived unfairness of the proposed tolls (especially if transport-related taxes are already high), their distributional effects (Viegas, 2001; Lave, 1994; Jaensirisak et al., 2005; Vonk et al., 2014; Jones, 2003; Schade and Schlag, 2003; Rentziou, et. al, 2011; Levinson, 2010) and scepticism as to their effectiveness (Jakobsson Bergstat & Garling, 2000; Cools et al., 2011). Congestion tolls are perceived as "sticks" while the public (and politicians as well) prefer "carrot" types of policies.

The political barrier to implementing congestion tolls led to policy innovations that aim to introduce the logic of congestion tolls while minimising public opposition. Efforts to increase road pricing acceptability have included: better communications with the public (Gaunt et al., 2007); showing that the pricing scheme benefits drivers individually and not simply the society at large (Schaller, 2010); using different framing of road pricing (Viegas, 2001); solving distributional problems by the free allocation of mobility rights (Viegas, 2001) and using "tradable driving credit" (TDC) (Dogterom et al., 2018[2]); dedicating toll revenues to public transport investments (Eliasson and Mattsson, 2006) or to cities (King et al., 2007); and increasing the fairness of the taxes by cutting or eliminating other taxes when implementing congestion tolls (Levinson, 2010). Yet congestion tolls with comprehensive spatial coverage remain rare.

However, congestion tolling is just one option within the broader concept of congestion pricing. Other innovative policies have been developed and implemented to introduce road pricing mechanisms, aiming at managing travel demand while hiding the sticks among the carrots or even converting sticks to carrots. Such strategies enable at least some of the benefits of a pricing mechanism in travel demand to be attained without vocal public and political opposition. This paper examines two policy tools that have been implemented in Israel: "high occupancy tolls" (HOT) and a positive incentives experiment.

Capacity management by high-occupancy toll

High-occupancy toll (HOT) lanes are a variant of the more common high-occupancy vehicle (HOV) lanes, which developed from "dedicated bus lanes" (DBL). As their names suggest, DBL can be used only by buses, and sometimes other public transport vehicles. HOV lanes differ in also allowing private vehicles with a sufficient number of persons on board (2+, 3+, 4+, etc.) to use the lane. HOT lanes also allow "low occupancy vehicles" (LOVs) that do not meet the relevant HOV threshold to use the lane if they pay a toll.

The first HOT lane facilities were introduced in California in the 1990s (SR91 and I-15). As of January 2019, there were 67 operating HOT facilities and 22 additional planned facilities (AHB35, 2019). HOT facilities

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vary greatly in terms of extent (length ranging from six km to 129 km); complexity, in terms of the number of entrances and exits; integration with other lane management options (express lanes with limited access, bi-directional operation changing by the time of day, etc.); toll mechanism; operating agency; and more. Table 1 provides information about operating HOT lanes.

To place the HOT concept in context, it is useful to consider it in terms of perspectives on tolls in general. Tolls can be viewed from two related but different perspectives: as a road financing or a travel demand management (TDM) tool, i.e., congestion pricing. The two perspectives influence the goals, the performance measures, and to some extent the reference points for evaluation. The goal of tolls in road financing is to fund infrastructure construction, thus enhancing available capacity. The goal of tolls in congestion pricing is to manage traffic, i.e., to influence traveller behaviour and thus increase the societal benefits gained from the existing capacity.

Table 1. Characteristics of operating HOT lanes

Characteristic	Description
State/country	TX (27); CA (9); FL (6); VA (6); CO (5); Other US (13); Israel (1)
Opening year	1995-2000 (2); 2006-2010 (3); 2011-2015 (11); 2016-2020 (19); NA (32)
Type	New (29); Conversion (17); New + Conv (10); NA (9)
Toll free occupancy	2+ (20); 3+ (14); All pay (9); NA (24)
Operation hours	24/7 (35); other (32)
Length (centre line km)	<=10 (4); 11-20 (10); 21-40 (12); >40 (5); NA (36)
Max toll (USD)	<10 (17); 10-20 (8); NA (42)
Desired speed	70-110 km/h (45-70 mph)

Source: AHB35 (2019).

Performance measures for congestion pricing projects must consider the level of service in terms of the travel times (or speeds) of various traveller groups. Other performance measures, and particularly measures related to utilisation (e.g., traffic volumes), are relevant for both congestion pricing and road financing projects. A common aggregate measure from the road financing perspective is total revenue. A common aggregate measure from the congestion pricing perspective is total person travel time, which may capture the key impact on social welfare, assuming that total demand does not change.

The performance of a policy action can be compared with the prior situation and the optimal situation. In toll roads that are motivated by the need to finance the infrastructure, construction financing by user-paid tolls expedites the process and thus contributes to social welfare relative to the prior situation as there is additional capacity paid for by users. On the other hand, the toll on the new facility can lead to under-utilisation, relative to the system-optimal situation. In these cases, from the congestion pricing perspective, a toll on a new road can be counterproductive, as other segments in the network become more congested, while the capacity of the tolled segment is not fully used. Therefore, to assess social welfare, it is necessary to weigh the impact of the toll on both the tolled road and the remainder of the network, including GP lanes.

The discussion on HOT lanes in the literature takes both congestion pricing and road financing perspectives and involves comparisons with both the prior situation and the system-optimum. It can be shown (Gardner, Bar-Gera and Boyles, 2013) that in many reasonable contexts, social welfare is maximised (and total person travel time is minimised) if the HOT lane capacity is exactly *fully utilised* (that is the lane traffic

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is not congested, but an increase in volume would lead to congestion). Since in practice the distinction between congested and uncongested traffic is not as crisp, an alternative operational condition is to ensure that speeds are above a chosen target value. In this sense, the justification for HOT projects is in line with the congestion pricing perspective.

The analysis of HOT projects may be different according to the prior situation. As shown in Table 1, most HOT projects in the US are based on new construction, so capacity is added. Among the 17 conversion projects, 15 are conversion from HOV, and one is conversion from a bus lane. In the remaining conversion project, as well as in the ten "conversion + new" projects, the database does not specify the conditions prior to the conversion. It would appear that, except for the case of Israel (see details below), the literature does not include reports on HOT lanes that involve conversion of capacity, which was previously available for general-purpose traffic.

Converting HOV to HOT is relatively easy to justify. First, many HOV have been under-utilised (Safirova et al., 2003.; Cassidy et al., 2006; Lipnicky and Burris, 2010). From both an economic and an operational perspective, given the high demand for road infrastructure, HOVs with excess capacity are wasteful. Thus, "selling" the excess capacity to additional users increases utility and welfare. Second, HOT enables the introduction of congestion pricing by choice, reducing public antagonism.

The motivations for HOT construction are also straightforward: the new capacity offers benefits to those who use it and to others who face less congestion in non-tolled lanes. Allocating resources (right of way, as well as financial) to a facility that focuses on public transport and HOVs may be easier to justify than adding highways that may induce additional demand. Finally, if the tolls are used to finance the construction, the policy package is more likely to be approved.

Several of the HOT projects are based on public-private-partnerships (PPP), some as build-operate-transfer (BOT), others using different procurement mechanisms. The partnership structure may add complexity to the goals of HOT initiation and operation, as reconciling the interests of the public agency and the private operator is not always easy. Conflicts are particularly likely if the public agency aims for optimal operation from a societal perspective since private operators pay more attention to revenues.

Very few studies have examined the issue of public acceptance of HOT projects. There has been some criticism that benefits accrue mainly high-income populations, as reflected in the nickname "Lexus lanes" (Levinson, 2010). However, critics seem to have had a minor effect on HOT implementation, and there is limited opposition to HOT among the public, unlike most other congestion pricing methods. HOT lanes have been found to be the most attractive policy for individuals (Harrington, Krupnick and Alberini, 2001). Levinson (2010) concludes in his review that HOT lanes are the pricing strategy least likely to raise public concerns. One possible explanation for the acceptance of HOT projects is the reference situation, i.e., the situation before HOT was introduced. As stated above, in many corridors HOT lanes provide additional capacity. When HOT has been applied to existing infrastructure, it has usually been by converting HOV to HOT. In both these types of HOT implementation, the change satisfies the Pareto condition of benefiting one group without making anyone worse off. The Pareto principle may also be satisfied on standard toll roads, where road pricing is adopted to enable/simplify/expedite construction of new capacity, unless there are objections to the construction due to environmental considerations.

While infrastructure utilisation is a major motivation behind HOT projects (especially when supporting HOT over HOV), there is little information in the literature on the level of utilisation of HOT lanes. Examination of the Washington State Route 167 HOT has found that capacity still exists to further accommodate SOVs (Zhang, Wu and Wang, 2010). A paper that examined the potential effects of converting HOV to HOT in two existing HOV facilities, I-270 and US 50 in the state of Maryland, found that utilisation effects are case-

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specific. While conversion is more beneficial for US 50, as highway utilisation significantly improves on the managed lane (VMT increased by 240%), the I-270, does not provide much benefit, since it leads to overcrowding and lower speeds similar to the parallel GP lanes (Fan, Erdogan and Welch, 2016).

Goodin et al. (2011) report on agencies' policies regarding the critical flow that should not be exceeded. Examples include 2 300 vehicles per hour, or 1 150 vehicles per hour per lane on I-25 in Denver Colorado; 1 300 vehicles per hour on the single HOT lane of I-10 in Texas; 1 300 passenger car equivalents (PCE) per hour on the single lane of El Monte Busway in Los Angeles, California, (where a bus is equivalent to 1.6 passenger cars); and 2 700 vehicles per hour or 1 350 vehicles per hour per lane on I-15 in California) Swisher et al. 2003). The toll policy on SR-91 appears to follow a slightly different approach, as monthly updates aim to achieve directional hourly two-lane flows within a fairly narrow range of 2 700-3 200 vehicles per hour. It is not clear whether these policies were adopted due to risk aversion regarding the level of service of the HOT lanes, or whether they are considered "full utilisation" in the sense described above.

From the perspective of the agency and the operator, a key question is how to set the price, and how to estimate the performance of a proposed facility *ex-ante*. Several studies address these challenges by embedding HOT lanes into simulation models, and by examining alternative algorithmic approaches for setting prices (e.g., Sachse and Leonhardt, 2009; Wang and Zhang, 2009; Chaudhury et al., 2011; Toledo, Mansour and Haddad, 2014; Horowitz, Kurzhanskiy and Wright, 2018).

HOT introduce road pricing within a comprehensive policy package, offering numerous alternatives: LOV using General Purpose (GP) lanes without paying a toll; LOV using HOT lanes, while paying a toll; and carpooling using HOT lanes, without paying a toll. Low occupancy vehicles that switch from GP lanes to HOT lanes reduce congestion on the GP lanes, and thus other users of the GP lanes benefit from the conversion. Assuming appropriate pricing levels, the level of service for public transport and HOVs remains high, possibly similar to the situation prior to the conversion. Two behavioural aspects have been examined empirically; the effect of HOT projects on carpooling, and the choice of HOT by LOVs.

It has been claimed that HOT installationsignificantly reduces car pooling (Guensler et al., 2019). Burris et al. (2014) examined carpooling on eight roadways with HOT lanes. As far as possible, data on the number of carpools on the facility in the year before and the year after converting from HOV to HOT lanes was examined. Overall, carpooling decreased on most corridors, stayed the same on a couple, and on one corridor that added HOT lanes (SR-91) carpooling increased. Despite these results, it is difficult to draw definitive conclusions as carpooling preference tends to vary by facility. There were also many exogenous factors affecting the amount of carpooling, while there is inherent difficulty in obtaining occupancy counts, while those counts can fluctuate greatly from day to day and month to month. Overall, however, it appears that HOV to HOT conversion often reduces carpooling rates.

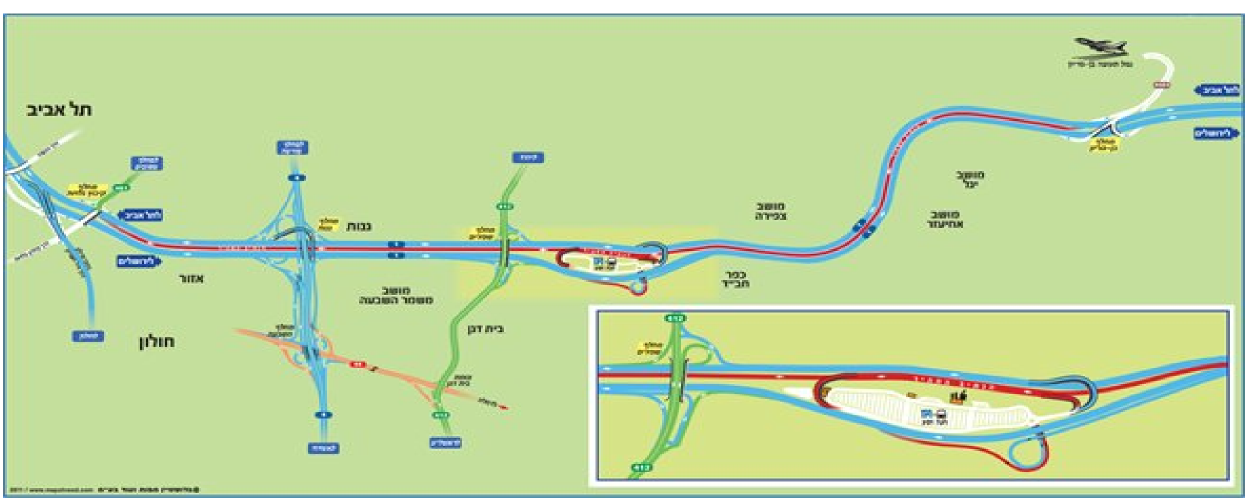
The second aspect concerns LOV choices and their probability of choosing paid HOT. Classical models of transport behaviour assume this is a function of certain objective travel measures, particularly the difference in travel time between HOT and GP and the HOT price. A commonly used model to depict HOT choice is Binomial Logit, where the probability is a non-linear function of a linear combination of price and time difference (e.g., Lou, Yin and Laval, 2011). Other studies have examined Value-of-Time (VOT) models, where HOT choice probability is a non-linear function of the ratio between time difference and price (e.g., Gardner, Bar-Gera and Boyles, 2013).

Empirical studies show that HOT choice prediction may be more complex, especially in corridors where travel time information is not presented together with price information. Janson and Levinson (2014) studied MnPASS corridors, where no travel times or congestion levels are made available to entering drivers. Their results suggest that HOT drivers are paying for more than just travel time savings. Another possible factor is reliability. Drivers may also view the price as an indication of time savings, with higher prices suggesting greater time savings. In a subsequent study of the same corridors, Janson and Levinson (2018) provide additional evidence that, in the absence of travel time information, the HOT price signals expected downstream traffic congestion. Thus, when prices are relatively low, an increase in price results in a higher HOT lane share since drivers expect greater congestion. However, there is a point past which the increase in toll outweighs greater time savings and reliability causing the HOT lane share to decrease.

High-occupancy tolls in Israel

According to the express-lanes database (AHB35, 2019), Israel is the only country outside the US operating HOT lanes. The existing facility is located along inter-urban freeway number 1, connecting Jerusalem (the capital) to Tel-Aviv (the business hub). It operates in one direction, towards the entrance to Tel-Aviv, starting near Ben-Gurion International airport, and ending at the merge of freeway number 1 with the urban Ayalon freeway (number 20). The facility opened to the public in January 2011. The facility is 13 km long and one lane wide. It has two entrances and one exit. Along most of its length, it is separated by a physical (metal) barrier, with paved shoulders. Towards the bottleneck at the end of the lane, the separation is by pylons. Figure 1 is a map of the Israeli HOT. The enlarged part in the bottom shows the parking area that serves as a possible point for mode shift, as described in Table 2. In addition to buses, the lane can be used without any payment by HOVs (the threshold changes by time of day between 3+ and 4+). Other passenger cars (LOVs) can use the HOT lane if they pay a dynamically updated toll, ranging from ILS 7 to 105 (~USD 2-30). Trucks and other heavy vehicles are not permitted. Additional exemptions from tolls include emergency vehicles, disabled drivers, etc. The algorithm for determining the pricing dynamically uses microscopic simulation (Sachse and Leonhardt, 2009). The Israeli HOT is a TDM initiative, aiming at affecting travel choice and thus improving the level of service without increasing the number of cars entering Tel-Aviv. Figure 2 shows average traffic volumes before (2010) and after (2011) the opening of the HOT lane at the first merging point of the lane and other lanes entering Tel-Aviv. Traffic volumes did not increase and may have declined slightly.

Figure 1. The Tel-Aviv HOT



Source: Hotze-Israel website at http://www.transisrael.co.il/template/default.aspx?PageId=153.

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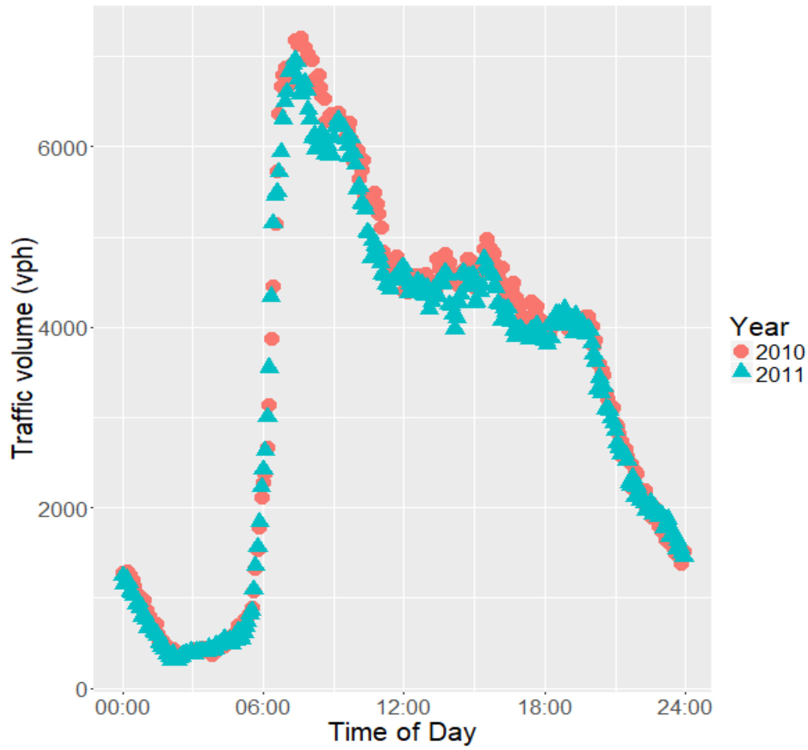
Figure 2. Traffic volume at the entrance to Tel-Aviv 2010 and 2011



The Israeli HOT lane may be seen as new construction since, for most of its length, the number of lanes has been increased, and the number of lanes available for general-purpose traffic is unaffected. However, the critical point in this corridor is the bottleneck at the end of freeway 1, where an overpass bridge restricts the potential number of lanes. Expanding the capacity of the bottleneck was also technically complicated for other reasons, including the nearby rail tracks and residential housing. Expanding the bottleneck capacity was also considered undesirable, as it would lead to increased traffic in Tel-Aviv, increasing congestion, pollution and road accidents. Given the fixed capacity at the bottleneck, the allocation of one lane for HOT implied reducing the number of through-lanes for general purpose usage from three to two. The slip-lane connecting to the Kibutz-Galuyot off-ramp downstream has been extended, allowing partial utilisation by approximately 600 vehicles per hour. Thus, in effect, the additional paved area increases the storage of the corridor, and postpones the spillback to the Ganot interchange upstream, but does not contribute to the throughput of the corridor. To summarise, the key difference between the Israeli HOT project and most others is that available GP capacity has been reduced by the project, resulting in the potential for GP travellers to experience increased congestion.

Two mechanisms were introduced to address the risk of increased congestion: a park and ride service and utilisation requirements. The latter were included in the terms of the BOT tender, specifying that speeds should be no less than 70 km/h and utilisation should be no less than 1 600 vehicles per hour whenever the toll is above its minimum value. The two requirements were chosen to achieve a balance between the level of service in the GP lanes (volume requirements) and the level of service in the HOT lane (speed requirements).

The integration between the park and ride service and the HOT facility is perhaps the most distinctive aspect of the Israeli HOT lanes, relative to the US practice. The original parking lot included 2 000 spaces, but the construction of additional floors to increase the parking lot capacity has recently begun, doubling capacity to 4 000 parking spaces. It is located near Shafirim interchange, about six km from the beginning of the HOT lane and offers several functionalities, as detailed in Table 2. The main one is the possibility to park a private vehicle for free and board a free shuttle to the Tel-Aviv CBD. LOVs that use the first section of the HOT lane to reach the parking lot pay no toll. The current shuttle services include two lines. Both utilise the HOT lane to bypass the congestion at the entrance to Tel-Aviv and then continue along the Ayalon freeway. Each line uses a different interchange (Hashalom and Arlozorov), and then makes several stops along relatively short circuits near high demand locations. Additional shuttle routes are planned, pending the parking capacity expansion. The shuttle service runs very frequently (every five minutes or less) during the peak hours, and less frequently (every 15 minutes) during other times (excluding nights and weekends).

Table 2. Alternative usage options for the Israeli HOT lane facilities and services

Usage option	Pay*	Park[2]	Relevant dynamic Information	Average workday Count (2019)
Drive alone	Yes	No	Price (travel time information3)	5 117 (S.D. 783)
Park and use free shuttle	No	Yes	Parking space availability	1 761 (S.D. 329)4
Park and carpool	No	Yes	Occupancy threshold; Parking space availability	Included above and below
Carpool from origin to destination	No	Yes	Occupancy threshold	724 (S.D. 123)5
Bus from origin to destination	No	No	No	1 340 (S.D. 128) busses and shuttles
Bus and shuttle	No	Yes	No	Included above
Authorised vehicle (security, disabled)	No	No	No	146 (S.D. 21)

Notes:
1 Needs to pay for toll or parking.
2 Needs to access the parking area, either to park or to validate occupancy
3 Travel time information is not displayed to drivers on signs along the way, although such information is relevant for their decision. The information can be obtained from other sources, e.g., navigation applications.
4 Parked vehicles at the park-and-ride parking lot, counted at 12:00 PM. By 9:30 the counts are 1679 (S.E. 311). Parking overnight is prohibited. Including parking either for shuttle or for carpool.
5 Including all HOVs.

Most HOT paying users are occasional, rather than regular, users. In the year to 30 June 2015, 56% of paying users used the HOT option once, 30% used the HOT two to five times, 8% used it six to ten times and 6% used it more than 11 times (Matat, 2016).

The parking lot is also used to arrange carpools, i.e., the participants in a carpool may arrive at the parking lot in several vehicles, park all but one, and continue in a single vehicle. Payment is not needed in this case, since access to the parking lot is free, parking is free, and the second section of the HOT lane from the parking lot to Tel-Aviv is free for HOVs. The parking lot also provides a second entry point to the HOT lane

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for HOVs as well as LOVs (who need to pay the toll). Finally, the parking lot serves as a terminal for several routes to Jerusalem, where regular transit fares apply.

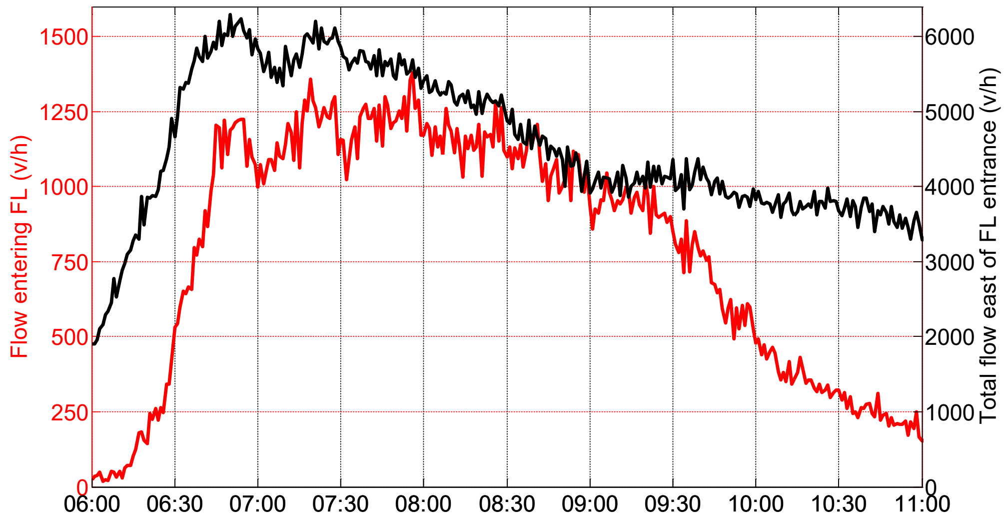
The Israeli HOT project is managed under a BOT tender, won by Shafir Ltd., and regulated by Hotze Israel Company, a governmental agency. The BOT agreement between the regulator and the private operator included various mechanisms to secure the project and its operation. The tender process requested a bid for subsidy for the construction. The state was surprised when the (winning) company, Shafir, offered a negative subsidy – i.e. they offered to pay the state for building the project. While the regulator had estimated that Israel would have to pay the contractor ILS 100 million, Shafir offered (and paid) ILS 182 million[3]. Shafir also bears the costs of the free shuttles to Tel-Aviv and all road maintenance and toll collection costs. Their revenues come from three sources: the tolls collected from LOVs that use the lane; a state subsidy of ILS 10 for every car parked during the morning peak; and a state subsidy in respect of vehicles exempted from tolls (high occupancy vehicles and authorised vehicles), except for the first 120 vehicles. It is not clear whether the project is self-financing once these subsidies are taken into account since the company does not disclose its financial data.

Figures 3-6 illustrate typical[4] values of key performance measures of the HOT lane to Tel-Aviv during its main operational hours – i.e. the morning peak (06:00-11:00). All four figures are based on 32 working days during June and July 2011[5]. Figure 3 shows the traffic volume at the eastern entrance to the HOT lane and the volume on road number 1, about one km east of that entrance. This reflects the potential demand for the HOT lane, as most of these vehicles continue to Tel-Aviv. This potential demand rises from ~2 000 vph at 6:00 to ~6 000 at 6:45, and then from 7:30 it decreases gradually to ~3 000 vph at 11:00. The pattern of HOT lane traffic is slightly different. During the peak, HOT lane traffic fluctuated in the range of 1 000 to 1 300 vph from 6:45 to 8:45, without a clear trend. Prior to the peak, HOT lane traffic remained negligible until 6:15, with a moderate increase to 250 vph by 6:30, and then a very quick increase during the next 15 minutes. Following the peak, HOT lane traffic decreased to ~250 vph by 11:00. To summarise, the main differences between HOT lane traffic and the demand are that the increase and decrease are sharper and later, and fluctuations are more substantial.

One of the reasons for the difference in traffic volume patterns is the differences in travel time. Figure 4 shows that the travel times in the HOT lane remain around seven to eight minutes during the entire period. Figure 5 shows the typical travel times in the GP lanes between 6:30 and 10:30. These reach a peak of 18 minutes between 8:00 and 9:00.

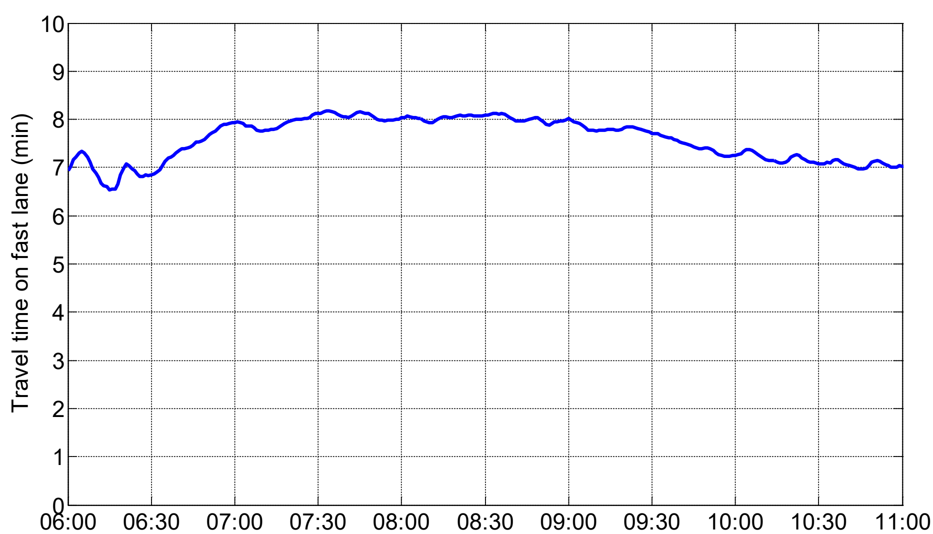
Figure 6 shows typical toll values for HOT users by time of day. During most of the day, a minimal toll of ILS 7 prevailed, except for the peak period of 6:45 to 9:30. The toll reaches a peak of ILS 30-35 between 8:00 and 8:30. Overall, the four figures illustrate that the facility is operating during the peak period more or less as could have been expected.

Figure 3. Traffic volume at the east entrance to the HOT lane and on road number 1, east of the HOT lane entrance



Notes: average values within the inter-quartile range, workdays of June and July 2011.

Figure 4. Travel time in the HOT lane by time of day



Notes: average of values within the inter-quartile range for workdays during June and July 2011.

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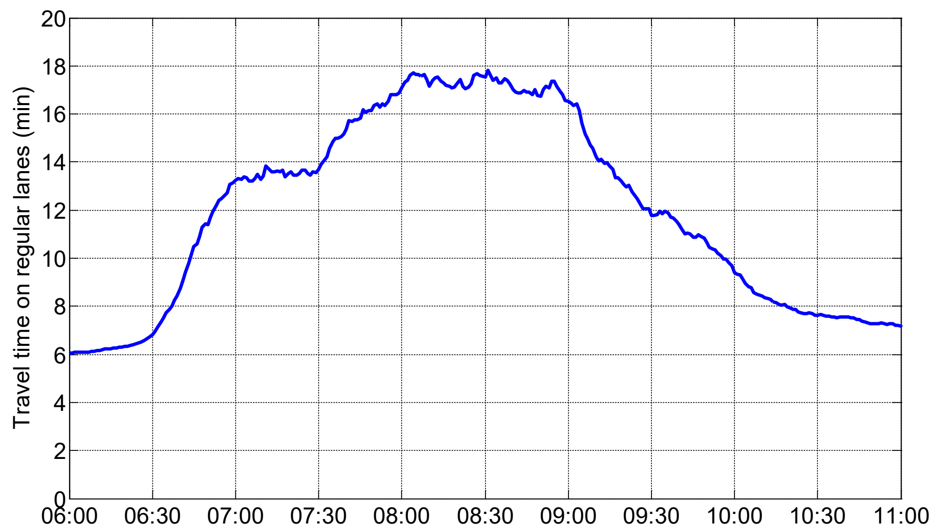
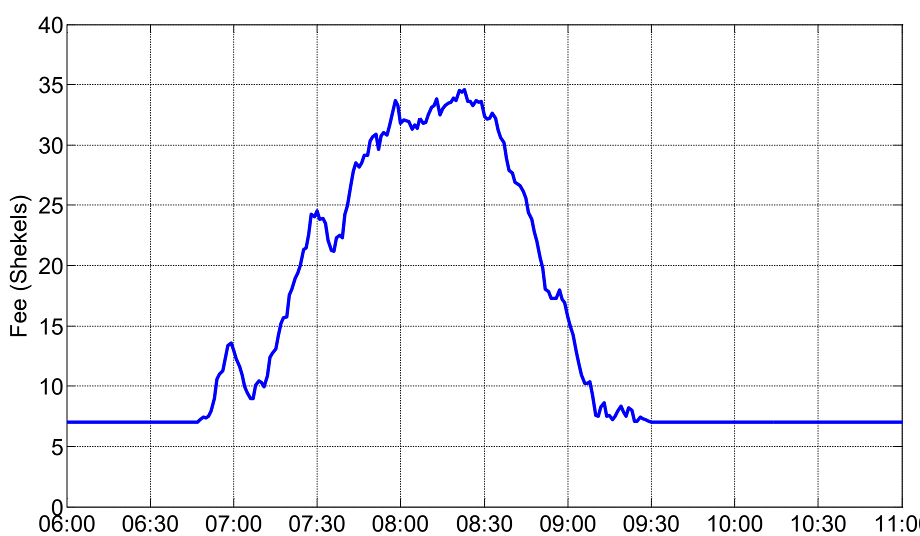
Figure 5. Travel time in the GPE lanes by time of day



Notes: average of values within the inter-quartile range for workdays during June and July 2011.

Figure 6. Tolls in the HOT lane by time of day



Notes: average of values within the inter-quartile range for workdays during June and July 2011.

The unique aspect of the Israeli HOT is the free shuttle service to Tel-Aviv co-located with the free parking lots. A survey of shuttle users was conducted in 2016 (N=890) (Matat, 2016). Findings show that 75% of shuttle users arrived at the shuttle station as car drivers, 14% as car passengers, 8% arrive by bus (three new bus routes from Jerusalem with the HOT parking lots as their final destination that were created after the HOT was opened) and 3% walked to the shuttle from nearby neighbourhoods. The vast majority of shuttle users walk to their final destination. Some 92% of trips made by shuttle users were work-related (commutes or business trips). Most of the commuters use the shuttle daily (67.7% on one shuttle line and

87% on the other) and most never use the HOT as paying drivers. In other words, the shuttle users tend to be regular users.

A subsequent survey of 530 shuttle users (Katoshevski-Cavari et al. 2018) found that most were commuters: 84% travelled to work, 73% usually arrive between 6:30 and 9:30, and 59% stay at their destination for more than eight hours. The destination of 73% is within a ten-minute walk of the nearest shuttle station; 95% of the respondents stated travel time reliability was an important or very important factor in their choice of the shuttle service, and 39% estimated that the service saves them more than 30 minutes of travel time. Parking cost savings are a typical motivation to use the shuttle service, as 72% do not have reserved parking near their destination, and 67% need to pay for parking at their destination (for 26% parking fees are paid by the employer, and 7% have free parking). Some 56% of respondents stated that they used their private car before the shuttle service commenced, implying that nearly half of the respondents (44%) switched from transit to multi-modal travel (by car to the parking lot and by shuttle to their destination).

Positive incentives

Theoretical aspects

In the last decade, an alternative to road pricing was suggested and promoted, i.e. moving from negative incentives (congestion tolls) to positive incentives. Positive financial incentives are proposed to encourage road users to change their travel time, mode or route to minimise congestion not by punishing unwanted travel choices but by rewarding the avoidance of such choices.

The most important difference between congestion tolls and positive incentives concerns participation. If the incentive is positive, participation can be voluntary. The expected level of public resistance should be lower, compared with mandatory participation. On the other hand, depending on the size of the incentives, participation may be partial, meaning that participants are those that have a higher incentive, i.e., those that contribute less to congestion. Road users that are less flexible are less likely to gain from positive incentives and therefore are less likely to participate. On the other hand, the larger the incentives that are given, the larger the segment of road users who will be willing to avoid congested roads. In sum, the effectiveness of positive incentives is likely to be lower than congestion tolls, but its public acceptability is likely to be higher.

Positive incentives as a road pricing mechanism have several other notable characteristics. From a behavioural perspective, there is difference between whether a situation is framed as loss or gain (see Kahneman and Tversky (1979) for theoretical foundations and Shiftan et al. (2017) for discussion of transport behaviour applications), as losses hurt more than gains feel good (loss aversion). Thus, the impact of incentives may not be as great as the impact of pricing. Therefore, it may be more effective to frame positive incentives as losses (i.e., offering a reward that is reduced when individuals travel at congested times).

From a distributional perspective, when a congestion toll is introduced, road users with less flexibility may have no choice but to pay the charge and are thus the main losers from congestion tolls. “Switchers” are

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typically those with fewer financial resources but flexible schedules. In the case of positive incentives, the "switchers" are rewarded for the change they made, and since they could have decided not to switch, their new situation is an improvement. Additional winners from positive benefits are car owners with a modest or low contribution to congestion, as they can receive an incentive without changing their behaviour. This component of benefit distribution may be seen as wasteful, as it does not inspire a change in behaviour. On the other hand, it may be seen as a justified correction of excessive taxation of car owners that do not contribute to congestion.

From an institutional perspective, reward is a budget expenditure that should be justified and budgeted, like all such expenditures. It should be evaluated at both the social welfare (or national economy) level and the financial level, i.e., in terms of the implications for the other elements of the budget. In particular, if the implementation is not tax-neutral, the additional taxes raised to finance the expenditure on incentives necessarily entail deadweight welfare losses.

The few empirical experiments with positive incentives report positive and significant results (Bliemer, Dicke-Ogenia and Etterma, 2010; Ben-Elia and Ettema, 2009, Abou-Zeid et al, 2008). The most comprehensive was the Netherlands "Spitsmijden" programme, rewarding peak hour travel avoidance (Ettema, Knockaert and Verhoef, 2010; Ben-Elia and Ettema, 2009; Leblanc and Walker, 2013). In this case, the normal behaviour of drivers was monitored prior to the planned construction period. Drivers who frequently used the facility under consideration at peak hours were offered a financial reward for avoiding such trips during the construction period. Overall, the Netherlands conducted four experiments in different areas that lasted between ten weeks and one year, with between 340 and 2 975 participants. Bliemer, Dicke-Ogenia and Ettema (2010) summarise the results, concluding that *peak avoidance rewarding (EUR 3 or 4) shifted about 50% of the trips made by participants*.

On a much smaller scale, the Minnesota yearlong experiment included 130 households, randomly divided into four groups, to examine different incentive schemes (Abou-Zeid et al., 2008). Although the small group sizes did not lead to statistically significant results, the elasticity of peak-period mileage was found to be negative, as expected.

The Israeli pilot: "Going Green"

In 2013, the Israeli government conducted a pilot with positive transport-related financial incentives[6]. The pilot was not designed for scientific purposes, but rather as a proof of a concept directed towards further development of positive incentive schemes. Following the results of this pilot, the Israeli Department of Transportation decided to perform a rolling operational experiment. The experiment will involve 100 000 participants and may be continued to full deployment. A call for tender for private companies to manage the experiment was published in June 2018 and currently (mid-2020) is recruiting participants.

The 2013 pilot sought to test whether positive financial incentives can induce changes in travel behaviour that will reduce congestion. 1 200 drivers volunteered to participate, for a two year period. An In-Vehicle-Data-Recorder (IVDR) was installed in volunteers' cars to monitor their travel patterns. Volunteers were presented with a pricing table and a map showing the travel cost by area and time of day (See Fig 7). The country was divided into three regions: metropolitan central areas, metropolitan fringe areas, and periphery. The week was divided into three time periods: a) peak time; b) midday; and c) evenings, nights and weekends. Illustrative prices per km were: ILS 1.5 (~USD 0.5) at peak periods in congested areas; and negative ILS 0.10 (~USD 0.03) in the periphery, enabling people who travel in non-congested areas to gain money, but significantly less than the cost of their travel, or even the tax they pay on their gasoline. Other prices are listed in Figure 2. The first four kilometres involve no charge and the maximum charge per trip was set to ILS 25.

Figure 7. Division of Israel to three regions of financial incentives and list of prices (ILS)

	Periphery	Metropolitan edge	Metropolitan area
06:45-09:30 15:30-18:30	-0.10	0.30	1.50
09:30-15:30 18:30-20:00	-0.10	0	0.10
20:00-06:45 weekends/holidays	-0.10	0	0

Values in the table are for vehicles with medium level of emissions. The price per KM for vehicles with high/low level of emissions was ILS 0.1 higher/lower respectively.

The two years of the experiment were divided into two periods. In the first period, which lasted six months, the travel patterns of the participants were tracked and analysed. This is considered the control period. The second period, of 18 months, is considered the incentive period and was further divided into two stages with different incentive schemes. In Stage 1, a travel budget was set, based on the participants' *ex-ante* travel patterns. Every trip influenced the budget, usually reducing it, as described above. The budget was set so that by the end of the month participants continuing with the same travel pattern would have a remaining budget of zero. However, participants could reduce their contribution to congestion, and thus have a positive remaining budget, which they could collect at the end of each month. In Stage 2, each participant received the same budget of ILS 2 600. At the end of each period, she would receive the difference between this amount and the congestion fees she had to pay.

Six hundred drivers participated in each stage. Stage 1 was intended more for drivers who were used to travelling intensively in congestion, while Stage 2 was intended for drivers who did not drive a lot in congested areas. The analysis that follows focuses only on Stage 1.

Participants could follow their travel patterns and the fees they accumulated on a website. At the end of each trip with a cost of ILS 7 or higher, an SMS summarising the details and cost was sent to the driver, unless they declined these messages. All participants completed a survey about their travel patterns and flexibility to change them before and after the experiment. Of 600 participants in the first stage, 431 were

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included in the analysis. The main reason for exclusion was changes in travel needs, due to change in residence or work location.

For privacy reasons, the calculation of each trip was made in the vehicle itself. Therefore, the only real-time information about car use was the calculated trip costs. There is no information about the spatial and temporal characteristics of the trips. Information about travel choices and behavioural changes is derived from a survey that the participants completed.

The results reveal an average reduction of 15.8% in trip costs between the control period and the incentive period. This was achieved via a drop of approximately 35% in costs among 43% of the participants, who accomplished this in various ways, as shown in Figure 8. Half of the participants did not change their travel behaviour and about 7% actually increased their travel cost for various reasons, possibly unrelated to the incentive. Among those who reduced their contribution to congestion, about half did it by changing the number of trips by private car, either by changing mode or working from home, and the other half by changing their departure time. In order to achieve an ILS 20 decrease in congestion cost per week, it was sufficient to give up one private vehicle journey or shift the time of day for one day per week. In practice, this is what many participants did. Those who shifted to public transport, worked from home, or joined a carpool, did so only for some of the days of the week, but still benefitted significantly from the incentives.

Figure 8. How participants changed their travel costs?

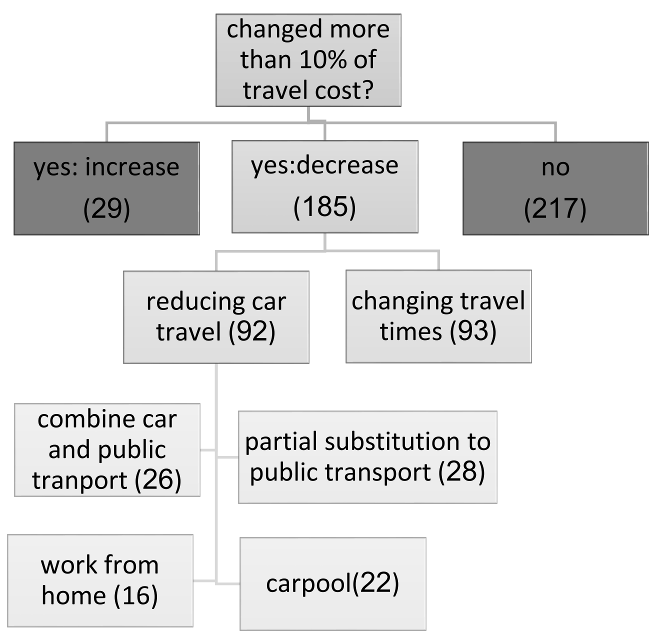
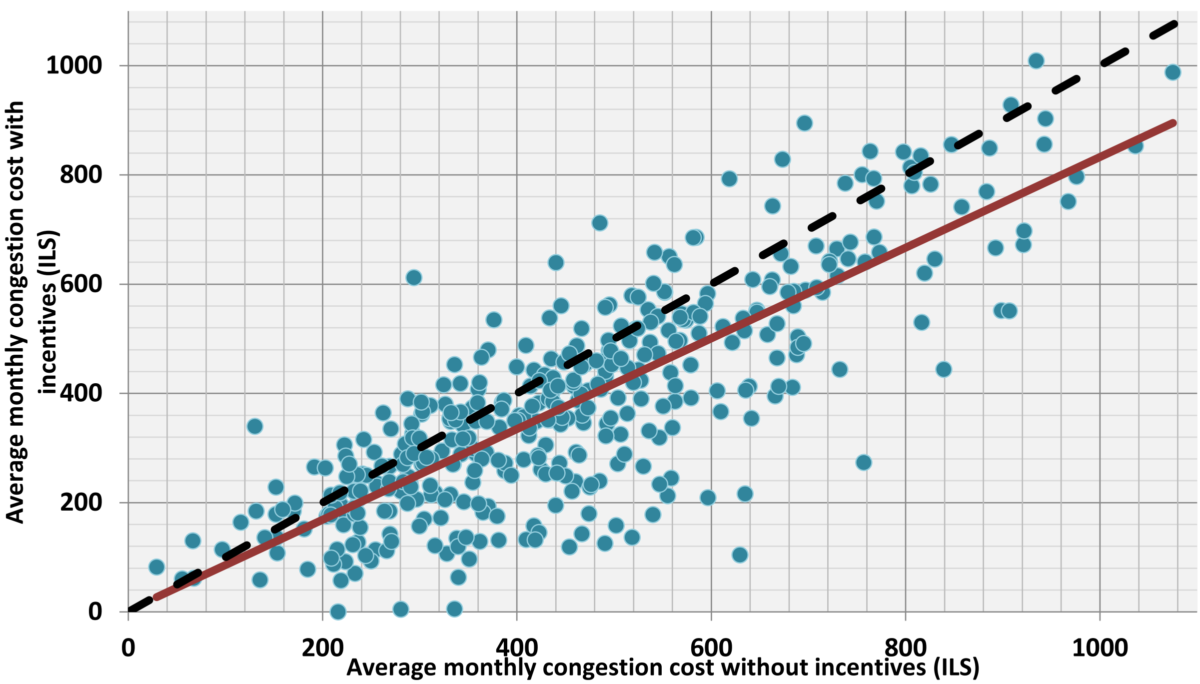


Table 3 shows the average change in cost for the different categories, and Figure 9 shows the changes in average weekly congestion costs between the two periods. The red line in Figure 9 represents equal costs between the two periods. Points falling below the line describe participants who reduced their travel costs. The blue line represents the overall trend line of all participants.

Table 3. Average change in cost for the main different categories

	Number (percentage)	Before Incentives (ILS)	With incentives (ILS)	Difference (ILS)	Rate of change
Reduce travel	92 (21.3)	103.9	62.6	-41.3	-39.7%
Time change	93 (21.6)	117.4	80.2	-37.2	-31.7%
Cost increase	29 (6.7)	73.3	104.7	31.3	42.2%
Change up to 10%	217 (50.3)	99.0	97.4	-1.6	-1.6%
Total	431 (100)	102.3	86.8	-15.5	-15.24%

Figure 9. Comparison of average monthly congestion costs per participant between the period without incentives (6 months) and the period with incentives (18 months)



It is interesting to compare the actual changes in behaviour in view of participants' expectations of their flexibility and ability to change, as revealed in their survey responses before the experiment. Table 4 shows the anticipated ability of the participants to change departure time to work and the perceived quality of the public transport option to work as self-evaluated by participants. Within each group, the table shows how many reduced trip costs were due to shifting departure time vs transfer to public transport. Table 5 presents similar results for public transport quality and congestion cost reduction by changes in mode of travel. As Tables 4 and 5 show, there is a positive link between the self-evaluations and the behaviour in practice, but the match is not perfect. For example, public transport was chosen (albeit in a limited manner) by those who thought that public transport access to their destinations was "not good", and time shifts were specifically taken by those who stated that they did not have any flexibility in this matter.

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Table 4. Stated departure time flexibility and actual congestion cost reduction by changing departure time

Stated flexibility of working hours	Count (percentage)	Respondents who reduced congestion costs by changing departure time (share within level of flexibility)
No. Workplace does not allow	45 (10.4%)	3 (6.7%)
Needs special permit from work	160 (37.1%)	39 (24.4%)
Workplace permits, but I cannot for other reasons	40 (9.3%)	6 (15%)
Flexible	186 (43.2%)	45 (24.2%)
Total	**431 (100%)**	**93 (21.6%)**

Table 5. Stated quality of public transport and congestion cost reduction by changing mode of travel

Stated quality of public transport for the respondent commute	Count (percentage)	Respondents who reduced congestion costs by changing mode (% within level of public transport quality)
Bad	80 (18.6%)	4 (5%)
Not good	109 (25.3%)	10 (9.2%)
Moderate	136 (31.6%)	21 (15.4%)
Good	82 (19.0%)	14 (17.1%)
Very good	24 (5.6%)	5 (20.8%)
Total	431 (100%)	54 (12.5%)

The majority of participants did not utilise carpooling at all during the experiment, with most claiming difficulty in finding suitable partners (with respect to location and departure/return time) was the primary barrier. In contrast, 21 participants turned their carpool journeys into a permanent fixture of their commute – especially when the majority of those were travelling with colleagues to work. Twenty-three percent of the overall reduction in private vehicle usage during peak hours and in metropolitan zones was accomplished via carpooling.

Half of the participants claimed an inability to work from home, due to their employment being unsuitable for remote work or due to their employer not accepting this practice. Only 3% could widely work from home. In practice, 16 participants increased their work from home hours, accounting for 18% of the drop in private vehicle usage during congested times.

Concluding remarks

In Israel, road traffic intensity, in terms of vehicle kilometres driven per kilometre of road network, is much higher than in other OECD countries (OECD, 2019). According to the Tomtom index, Israel is the 21st worst in the world in terms of congestion severity, and the worst among European countries[7]. Thus, the urgent need to address traffic congestion has forced decision makers to initiate both long- and short-term policies. Along with massive investment in rail infrastructure (both urban and interurban), creative policies have been initiated to accommodate politically feasible solutions to traffic congestion in the short run. Both projects, the HOT lane and positive incentives, introduce the logic of congestion pricing via mechanisms that draw less public opposition than traditional congestion pricing approaches.

HOT lanes are generally less politically challenging as, in many corridors, HOT lanes do not reduce GP capacity. However, the Israeli case did reduce GP capacity since, at the merging point between the HOT at the end of freeway 1, a GP lane was converted to HOT. In order to reduce the impact on congestion for GP traffic, efforts were made to offer various alternatives using HOT and attracting many types of users. Combining a large parking lot with free shuttles or a meeting point for carpooling offered multiple alternatives and increased the number and types of travellers benefiting from the HOT.

The project began with suspicious public and media opinion, but became a success and is inspiring further HOT projects across Tel-Aviv. The positive incentives pilot, Naim Leyarok, used a different strategy to reduce public opposition. By offering compensation to drivers who do not use peak-hour congested roads, the pilot demonstrated use of congestion pricing without explicit sticks. First, non-participators do not lose (although the general public does finance the plan) and, second, participants do not lose; at worst they do not gain. The pilot demonstrated that with monetary incentives some people modify *some* of their travels. The voluntary aspect of the pilot excludes users of heavily congested roads and thus may be less effective compared with congestion tolls. However, aiming at partial travel modifications from a sub-population may have a significant overall impact. As long as congestion tolls are not feasible from a political perspective, positive incentives may help introduce a road pricing mechanism. However, moving from tolls to rewards moves the policy challenge from a political challenge (initiating an unpopular policy) to a welfare challenge (justifying the budget needs of the policy).

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Notes

1 There is currently a new offer on the table in NY: https://www.nytimes.com/2018/03/31/nyregion/congestion-pricing-new-york.html

2 TDC framework is studied extensively in recent years, suggesting that allocating driving credits and encouraging trade between users has the potential to reduce overall distance driven and gain higher public support compared with congestion tolls (Harwatt et al., 2011; Bristow et al., 2010; Kockelman and Kalmanje, 2005).

3 Since the building requirement evolved through the project implementation, Shafir deducted its extra construction costs and paid just the remaining sum.

4 As a typical value for each minute in the day the figures present an average over all workdays, excluding the first and last quartile. This measure is not as sensitive to outliers as the average, while avoiding the sensitivity of the median to discrete nature of some of the values (and particularly the toll).

5 (Sunday through Thursday, not including the Shavuot holiday), Also excluded are June 29th (due to missing data) and July 3rd (due to an accident within the HOT lane).

6 The description here is based primarily on publicly available documents (mostly in Hebrew).

7 https://www.tomtom.com/en_gb/traffic-index/ranking/

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Congestion Pricing with Minimal Public Opposition

This paper reports on the Israeli experience with a high-occupancy toll (HOT) lane between Jerusalem and Tel Aviv. It highlights the integration of a park-and-ride service with the HOT lane and the provision of free parking to encourage carpooling. The paper also analyses Israel's pilot "Going Green" programme and how it demonstrates the potential of positive incentives to address congestion.

All resources from the Congestion Control Experiences and Recommendations Roundtable are available at: https://www.itf-oecd.org/congestion-control-experience-recommendations-roundtable.

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